

Closed reduction and percutaneous pinning of displaced supracondylar fractures of humerus in children with delayed presentation

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【Abstract】 Objective: Supracondylar fractures of the humerus account for 60% of all the fractures around the pediatric elbow and even in developed countries 18% of patients undergo surgery 48 hours or longer following presentation in the hospital. Management guidelines are not clear yet for these patients who present late. The aim of this prospective study was to evaluate the clinical, radiological and functional outcome following closed reduction and percutaneous pinning of widely displaced supracondylar fractures of the humerus presenting 12 hours or more after injury.

Methods: We reviewed the functional and radiological results of closed reduction and percutaneous pinning using crossed K-wires in 40 patients with displaced extension type supracondylar fracture of the humerus (Gartland type III) with a delay of more than 12 hours in presentation. The average age of patients was 4.5 years and the mean delay in

presentation was 17.55 hours.

Results: Closed reduction and percutaneous pinning was successful in 90% of patients. The mean follow up period was 15 months. The Baumann's angle was restored within 4 degrees of the unaffected side in all patients. Use of a small medial incision in patients with severe swelling helped us avoid ulnar nerve injury. Using Flynn's criteria, 38 patients (95%) had an excellent result. Two patients had mild myositis and both had a poor result. None of the patients developed cubitus varus.

Conclusion: Closed reduction and crossed pinning of displaced supracondylar fractures of humerus in children is a safe and effective method even with delayed presentation.

Key words: *Fractures, bone; Humerus; Pediatrics; Fluoroscopy*

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Supracondylar fractures of the humerus account for 60% of all the fractures around the pediatric elbow.¹ Closed reduction and percutaneous pinning under fluoroscopic guidance is the procedure of choice for the treatment of these fractures whenever possible and the original Swenson technique of cross pinning continues to be used today with excellent results and low morbidity.^{2,3} Delay in surgical interven-

tion may result from delay in the presentation of the patient to the emergency department or delay on the part of health facility in form of unavailability of operation theatre or trained personnel. In the developing world, proportion of delayed presentation is much higher because of poorly developed health delivery system and patients reaching the tertiary care centers from long distance.

The management guidelines are not clear for these patients who present late. Several methods have been used for treating such patients including closed reduction and use of splint, traction with or without delayed internal fixation,^{4,5} closed reduction and percutaneous pinning,^{6,7} open reduction and internal fixation^{8,9}. Fractures which present late are difficult to treat because of excessive swelling and may be associated with complications, such as neurovascular injury, compartment syndrome. There is fear of perioperative and late postoperative complications like iatrogenic nerve injury, Volkmann's ischemic contracture, cubitus varus deformity, elbow stiffness and myositis ossificans.¹⁰⁻¹³

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Other studies have refuted the fears of high perioperative complication rate with delayed elective surgery but none has evaluated the long term functional outcome of the patients.^{6,14-16} The aim of this prospective study was to evaluate the clinical, radiological and functional outcome following closed reduction and percutaneous pinning of widely displaced supracondylar fractures of the humerus presenting 12 hours or more after the injury. The incidence and causes of failure were also discussed.

METHODS

Between July 2003 and June 2007, 88 patients with displaced extension type supracondylar fractures (Gartland type III¹⁷) of the humerus were treated at our institute, which is a tertiary referral center. Fifty-five patients with Grade III fractures (Figures 1A and 1B) presented more than 12 hours after injury. Five patients with age more than 12 years, other patients with associated injuries in the ipsilateral limb or with inaccurate recording of delay at presentation were not included in study. This left fifty patients available for inclusion in the study. Closed reduction under general anaesthesia with fluoroscopic control and crossed percutaneous pinning using two K-wires were successful in 45 patients and 5 patients required open reduction and internal fixation by cross pinning. Five patients were lost to follow-up and were excluded from the study. The remaining forty patients were followed up for a minimum period of 12 months and formed the basis of this study.

On presentation, age, gender, injured side, dominant side and exact delay at presentation after injury were recorded for each patient. A thorough clinical evaluation was done with particular emphasis on condition of skin, compartment syndrome and neurovascular status of the limb. Fracture reduction was done in casualty department only if radial pulse was not palpable or fracture fragment tented the skin. All fractures were splinted in 30° of flexion. Extremity was kept elevated to promote venous outflow and to reduce and prevent swelling. Radiographs of opposite elbow were also taken to measure normal Baumann's angle for that patient and for assessment of adequacy of postoperative fracture reduction. All the patients were operated under general anesthesia within 6 hours of presentation in the emergency department.

There were 26 boys and 14 girls. The average age

of the patients was 4.5 years (range: 2-9 years). Fall on the outstretched hand was the mechanism of injury in 36 patients, and the other 4 patients were pedestrians struck by a motor vehicle. Thirty-two patients had fractures of the dominant extremity. In 33 patients the fracture was displaced posteromedially (Figure 1), in 5 patients posterolaterally and 2 patients had posterior displacement. The average delay in presentation was 17.55 hours (range: 12 hours-3 days). Four patients had one or more attempts at reduction before they presented to us. Two patients had previous history of massage. Five patients (12.5%) had neurologic complications at presentation to the emergency room. Three had anterior interosseous nerve palsy while 2 had radial nerve palsy. Grade I open wound was seen in two patients with widely displaced fractures. The puncture wound was on the anterior aspect of the lower third of the arm in both cases, and none of the patients had a neurovascular injury. Five patients had absent radial pulse at initial presentation, but capillary filling was adequate in all. The pulse was restored in 4 patients following closed reduction. In one patient, the radial pulse did not appear after the closed reduction and the capillary was deteriorated. The brachial artery was explored through an anteromedial approach and a rent was repaired, then the distal circulation was restored. All operations were done under general anesthesia.

Closed reduction and percutaneous cross pin fixation was done with the technique originally described by Swenson et al³. Following fracture reduction, elbow was immobilized in hyperflexion using adhesive strapping to facilitate intraoperative radiography and pinning.¹⁸ When gross swelling made palpation of medial epicondyle difficult, a miniopen technique was used for placement of medial wire as described by Green et al¹⁹. Once K-wires were passed (Figure 2), the elbow was extended, radial pulse palpated and the carrying angle and stability of reduction was assessed.

The K-wires were left outside the skin after being bent at right angles. An above elbow plaster slab was given in 45° flexion of the elbow. K-wires were removed at 3-4 weeks after obtaining an X-ray image post-operatively to assess union (Figure 3) and myositis ossificans. At each follow-up, the carrying angle, range of motion of both the elbows and distal neurovascular status were recorded. Outcome was graded according to Flynn's criteria.²⁰

RESULTS

Forty-five patients were successfully treated with closed reduction and cross pinning. Five patients were lost to follow up. Forty patients with a minimum follow-up period of 12 months formed the basis of this study.

Open reduction through medial approach was needed in 5 patients. The mean delay in presentation in these five patients was 27 hours. In all these patients, there was buttonholing of the proximal fragment through the brachialis muscle, which prevented closed reduction.

The average anesthesia time was 42 minutes (range: 20-60 minutes). Thirty-seven patients were treated with 2 crossed K-wires. In 3 patients with unstable fracture, 2 lateral K-wires were employed in addition to the medial K-wires. In 15 patients, a small medial incision was used over the medial epicondyle to retract the ulnar nerve and help in passing the medial pin. With this technique, we had no iatrogenic nerve damage.

The mean hospitalization time was 12 hours. All the fractures united. The average duration of plaster immobilization and pin fixation was 21 days (range: 19-28 days). There were 3 cases of superficial pin tract infection that were successfully treated by local dressing and antibiotics. No cases of deep infection were

encountered. Elbow mobilization was started after the pin removal and full range of motion was achieved in 38 patients by the end of 3 months. Two patients had myositis ossificans and both had restriction of elbow flexion and extension. Both the patients presented 48 hours following the fracture with history of repeated manipulations by a quack, which is a common practice in remote areas of our country. All 5 patients (12.5%) with neurologic complications at presentation to the emergency room recovered within 12 weeks. None of the patients had postoperative neurovascular injury, compartment syndrome or Volkmann's ischemic contracture. Five patients had absent radial pulse at presentation. Among them, four patients restored the radial pulse following closed reduction of the fracture and percutaneous pinning, one patient required exploration and brachial artery repair.

The average duration of follow-up was 15 months (range: 12-24 months). All fractures healed in good alignment, with the Baumann angle within 4 degrees on the unaffected side. The carrying angle as measured with a goniometer was within 3° of the unaffected extremity in 38 patients at final follow-up. Carrying angle could not be commented upon in the 2 patients with loss of extension. None had a cubitus varus deformity. Based on Flynn's²⁰ criteria, 38 patients (95%) had satisfactory results.



Figure 1. A: Anteroposterior radiograph shows type III supracondylar fracture of humerus; B: Lateral radiograph shows type III supracondylar fracture of humerus. **Figure 2.** Intraoperative photograph after reduction and fixation with two crossed K-wires. **Figure 3.** Anteroposterior and lateral radiographs shows evidences of fracture union.

DISCUSSION

Closed reduction and percutaneous pinning under fluoroscopic guidance is now the accepted standard treatment for displaced supracondylar fractures of the humerus.^{2,12,21-23} Ours is a tertiary referral center with patients being referred from as far as 200 km and therefore late presentation is quite common. There are concerns about higher incidence of serious perioperative

complications and inability to achieve satisfactory reduction while treating these patients. Various potential complications include higher risk of myositis ossificans, loss of motion and infection in open procedures and higher incidence of inadequate reduction, conversion to open procedure, compartment syndrome and unsatisfactory functional results in closed procedures.¹⁰⁻¹³ Many authors have recommended emergent treatment of these fractures to reduce frequency of such complications.^{24,25} The

results of our study indicate that the majority of widely displaced supracondylar fractures of the humerus even with a delay in presentation of up to 72 hours can be safely treated with closed reduction and percutaneous pinning with excellent clinical results and without undue prolongation of the hospital stay as seen with other modalities of treatment.

A major concern with delayed treatment is the inability to achieve satisfactory closed reduction because of swelling, thus produce higher chance of conversion to open reduction. The rate of conversion to open reduction has been reported in literature as ranging from less than 3% to up to 46%.^{22,26-28} In our series, closed reduction and percutaneous pinning was successful in 90% of the patients, and only 10% (5 out of 50) required open reduction. Gupta et al⁶ reported a 6% rate of open reduction when only Gartland type III fractures were considered with a delay of more than 12 hours. Mehlman et al¹⁶ reported a conversion rate of 3% for delayed treatment group (>8 hours in that study). Buttonholing of the proximal fragment through the brachialis muscle was the only cause of failure of closed reduction in our patients, which is unrelated to delay in surgery. Archibeck et al²⁹ reported entrapment of brachialis muscle as a cause in 90% of irreducible supracondylar fractures. We did not attempt milking maneuvers described to free the entrapped muscle because of fear of myositis ossificans.

There was no correlation between an increase in time to surgical intervention and longer operative time or need to open the fracture site, nor was there an indication that the delay in surgical treatment resulted in a longer hospital stay or an increase in unsatisfactory results. Similar observations were made by previous studies,^{6,14-16} but none of them reported long term functional outcome of the patients. The current study showed excellent long term functional results in patients with 12-72 hours delay in presentation treated with closed reduction and percutaneous fixation.

Deep infections and osteomyelitis following fixation of supracondylar fracture are rare, while pin tract infections are common, which usually heal well with oral antibiotics and removal of wires. Infection rates of 2%-6.6% have been reported with percutaneous fixations.^{27,30,31} In the present series, 3 out of 40 patients (7.5%) developed pin tract infection. All the infections healed after removal of K-

wires with short course of oral antibiotics.

Percutaneous pinning enabled us to immobilize the elbow in less than 90° flexion in postoperative period, facilitating venous outflow and significantly reducing the risk of compartment syndrome.³² In addition, it prevents tenting of ulnar nerve^{9,33} and allows healing of the brachialis in a slightly elongated state which hastens regaining of extension during mobilization.² None of the patients developed compartment syndrome. Leet et al¹⁵ reported similar observation and suggested that vascular injury at the time of trauma is a bigger predisposing factor for development of compartment syndrome than delay in surgical intervention.

Although modern pinning techniques have reduced the incidence of cubitus varus deformity, this continues to be the most common complication following supracondylar fractures of the humerus.^{4,15,34,35} The cause of deformity is coronal rotation or tilting or a combination of both of the distal fragment.^{14,36,37} The most important factor correlating with the final varus deformity following closed reduction and percutaneous pinning is the difference in Baumann's angle between the operated and normal side.^{4,31} In all the patients, Baumann's angle was restored to within 4° of the uninjured side. In addition, other criteria like the restoration of the clear space between the olecranon and capitellum and transection of the capitellum by anterior humeral line on the lateral radiographs were also employed. Also, the clinical carrying angle was assessed by fully extending the elbow after the cross pinning was complete. None had cubitus varus deformity at a minimum follow-up of 1 year. Our study results agree with other studies, which have reported that cubitus varus is caused by inadequate reduction.^{20,21}

None of our patients had a loss of reduction during follow-up. Both clinical and experimental data have shown that two crossed pins placed from the medial and lateral condyles provide the greatest resistance to rotational displacement of the fracture fragment.^{3,38-41} The primary concern with cross pinning is the risk of injury to ulnar nerve by the medial pin. The frequency of this complication in reported series ranges from 0 to 5%.^{9,23,28,33,42,43} The necessity to hyperflex the elbow during the reduction, tendency of the hypermobile ulnar nerve to sublux anteriorly and blind passage of the medial pin all contribute to ulnar nerve injury. The use

of a small medial incision over the medial epicondyle in those cases with severe elbow swelling helped to prevent ulnar nerve injury.¹⁹ Cross pin fixation was the preferred procedure when this study was undertaken, as the configuration was considered more stable. The recent studies show two lateral entry pins to be as stable as cross pinning and no risk of iatrogenic ulnar nerve injury,⁴⁴ so the method has already been adopted as the method of choice in our institute.

In our series, 95% of patients had excellent results. Poor result was seen in 2 patients with more than 15° loss of extension and flexion of the elbow. The loss of range of motion in both patients was caused by myositis ossificans. Both of them presented 48 hours after injury with history of massage and repeated manipulations, which added to the initial soft tissue injury and may contribute to the poor result in these patients.

Studies have demonstrated no increase in perioperative complication rates with elective overnight delay in surgery,^{6,14-16,45} yet none of those articles have evaluated the functional and long-term results of such patients who were treated late. This prospective study shows no higher rates of perioperative complications and excellent functional and cosmetic results at mean follow-up of 15 months in patients treated with closed reduction and percutaneous K-wire fixation more than 12 hours after trauma.

In conclusion, the results of the present study show that closed reduction and crossed pinning of displaced supracondylar fractures of humerus in children is a safe and effective method even with delayed presentation. Use of strict intraoperative criteria to obtain anatomic reduction and stable fixation minimizes the risk of development of cubitus varus deformity later. Mini-open technique for placement of medial pin in cases with severe swelling reduces risk of iatrogenic ulnar nerve injury.

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